Commencement Exercises

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"The New Enterprise in Space"

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It is customary at commencement exercises to talk about the future--and there is no reason why this one should be any different. I want to talk about the future--the long term future--but I also want to extrapolate from the recent past.

Just a short four years ago, in 1980 when most of you were just finishing high school, it had been almost seven years since any Americans ventured into space. Now, four years later we have some really remarkable events behind us, and it is from these achievements that I will try to draw the picture of the future that I promised. In April 1981, we flew the Space Shuttle "Columbia" for the first time and put Americans back in space. This flight was important because it was the first successful mission of a remarkable, reusable space ship and it marked the introduction of a new "quantum jump" in space technology. In the fall of 1982, the first operational flights of the Space Shuttle were conducted and the first commercial satellites were placed into orbit by the Shuttle. In November 1983, the first Spacelab mission was successfully carried out in which, for the first

time, scientists in earth orbit--not astronauts, but scientists--carried out experiments while they were in close real time contact with colleagues on the ground. Most recently, you are all familiar with the mission that was conducted to pick up a satellite that had failed in orbit--the "Solar Max"--and to repair and redeploy it.

All of these pioneering missions were successfully executed during the last four years. They are a remarkable example of what can be done in a few short years if some new technology--the Space Shuttle in this case--is available for exploitation. President Reagan and a number of his senior advisors were very interested in these achievements, and, as a result, they saw what might be accom- plished by establishing for mankind "a more permanent presence in space." Indeed, President Reagan used this phrase in a speech two years ago in which he already hinted at what he eventually would say in his State of the Union message last January 25. As you all know, it was in his State of the Union message that the President directed NASA to start the development of a permanently manned orbiting Space Station, thus taking the next large step of mankind's movement into space. This Space Station will have a permanent crew of six to eight people, it will be placed in earth orbit in 1991 or 1992 and it will cost a total of about eight billion dollars. By the time you leave graduate school or are well started on your professional careers, the Space Station President Reagan has in mind will be orbiting the earth.

Why did the President think the Space Station proposal was sufficiently important to be included in the State of the Union message? What does the Space Station have to do with the future? Where will the Space Station take our "Enterprise in Space" that we have been engaged in now for a quarter of a century? There are four important reasons why a Space Station is important:

(1) The Space Station is a symbol of national leadership and competence in technology. Political symbolism is important. We have learned this the hard way by missing out on the first orbiting satellite, Sputnik I, in 1957, and on Yuri Gagarin's first epoch making orbital flight in 1961. The Russian political leadership understood this point better than we did two decades ago and, therefore, took the lead in the early days of the space program. We have since recaptured the lead, and it is important that we maintain it and that we use it to join hands with our friends and allies around the world. President Reagan underscored this point by formally inviting our friends and allies to join us in the development and the construction of the Space Station. Imaginative initiatives of this kind have often had enormous political impact that have a value much beyond the funds that are expended on them.

(2) The Space Station is a laboratory in earth orbit on which a great many scientific experiments can be performed that would be impossible to do on the ground. Included among these are biological experiments to determine the reaction of living things to zero gravity; certain chemical, physical, and fluid processes that can be carried out only in zero gravity; and many

astronomical and astrophysical observations for which the absence of an atmosphere is an advantage.

(3) A Space Station is a repair and maintenance base from which important satellites could be reached, retrieved, and maintained or repaired. The United States now has deployed in earth orbit well over 150 satellites, many of which perform missions of great importance to our national security and others that are commercially very important. Right now, all of these satellites are eventually discarded when they run out of fuel or when various components reach the end of their lifetimes. The Space Station and the associated orbital transfer vehicles will eventually make it possible to maintain and service all of these satellites while they are on orbit. Satellites will, therefore, eventually become "permanent orbital facilities" that will be repaired, maintained, and upgraded as required. The Shuttle flight conducted last month, during which a failed satellite (the "Solar Max") was retrieved, repaired, and redeployed foreshadows, in a small way, the kind of operation that will become routine once the Space Station is completely operational.

(4) The Space Station is a staging base for future missions. It is this point that I would like to discuss because it is this that will not only be most interesting but that is also most important in looking at the long term future.

First, a little physics. Why do we need a staging base at all? The fact is that in terms of energy expended, earth orbit is more than half way to any reasonable objective in the solar system. Thus, just as mountain climbers have base camps halfway

up the mountain as supply depots, so a Space Station will serve the same function for space travelers. Second, the ships used to get from here to the Space Station are very different from those used to go elsewhere. Most rockets we have built, including the Shuttle, are hybrids that are designed to fly both in the atmosphere and in space. As such, they are compromised--that is--they are not really very good machines for flying through the air nor are they true space ships. Rather, the Shuttle, for example, was specifically designed to do both. The wings, the tail, the tiles for thermal protection, and the control surfaces are useless in space, yet they must be taken along if the Shuttle is to perform its intended function even though they are all dead weight once space is reached. Thus, an efficient space ship would look very different from the Shuttle and much more like the Lunar Landing Vehicle used during the Apollo program. It would have only those features that are essential for space flight and it would not have those necessary for flight in the atmosphere. Such true "space ships" would be based at the Space Station along with an appropriate fuel storage depot--perhaps using expended external tanks of the Space Shuttle placed in earth orbit near the Station on various Shuttle missions. These true space ships based at the Space Station would then make the trips into the solar system that will constitute the next adventure in space.

The first step will be to go back to the moon and to establish a permanent base there. I am convinced that this will be done easily within your lifetimes, and my guess is that some future President a decade hence will adopt the establishment of a

small lunar base as an appropriate way to mark the start of the third millenium on January 1, 2000. We are already beginning to think about what we will do once we have such a base. (There was a conference of experts last month at Los Alamos, New Mexico, that marked a major milestone in the development of plans to determine what would be done with a lunar base once it is established.)

What happens after that? It is at this point that I want to share some really intriguing speculations with you that have come to public notice recently. Just as the Space Station, the lunar base is a means to an end, and it is the startling and breathtaking end that some people see which I want to dwell upon for a few minutes. Our "Enterprise in Space" has often been compared to the early ocean voyages of the 15th and 16th centuries as European explorers opened up the known world. This analogy is a good one as far as it goes. It accounts for the importance of developing new technology to overcome new problems. The combination of the sturdy Atlantic hulls of the 15th century carracks with the handy Mediterranean fore-and-aft rigged lateen sails of the ancient Arab dhows led to the creation of the famous caravels that were employed in the epic voyages of discovery. The study of astronomy and the creation of new instruments to measure with unprecedented accuracy the position of various stars led to practical methods of long range navigation at sea. These are only two examples, but there is no doubt that the sustained development of new technology which began with the "Age of Discovery" set the stage for what the early ocean explorers did and also for how we do business today.

There was indeed even the example of what happens when the urge to explore and also the development of new technology are forcibly curtailed. During the Ming Dynasty in China, in the early years of the 15th century, the great Chinese Courtier and Admiral, Chen-Ho, mounted a number of great voyages around the rim of the Indian Ocean. Chen-Ho's fleets visited Indo-China, India, the Islands of Indonesia, and even the east coast of Africa. His expeditions were enormous enterprises using the very best technology available. Between 1405 and 1433, seven expeditions of this kind were mounted. One of these had some 60 ships with aggregate crews of more than 25,000 people. This fleet made an extensive voyage of discovery and trade around the Indian Ocean and undoubtedly had an enormous impact wherever it went. Chen-Ho's ships were very large by the European standards of the day, the largest being 450 feet in overall length--compare this to the "Santa Maria's" 125 feet. His ships featured watertight compartments and efficient, bamboo-stiffened fore-and-aft rigged sails which allowed them to tack against the wind. And yet, all of this was halted as quickly as it started. Upon the death of the Ming Emperor Yung-Lo, in 1424, Chen-Ho was eventually deposed and his undertakings were ruthlessly terminated. Indeed, there is a record of a statute promulgated shortly after Yung-Lo's death which prohibited the construction of ships with more than two masts lest they be used once again to explore the unknown. The conservative Confucian mandarins who came to power after Yung-Lo's reign as the new Emperor's principal advisors won the battle to shut off the spirit of enterprise and exploration in China for centuries to come. To do that, they not only

prohibited the voyages but also the creation of the technical means to carry them out.

One wonders what would have been the course of history had a Chinese fleet dropped anchor in San Francisco Bay a century before the Pilgrims landed in Massachusetts. Certainly, it was a technical possibility in 1424 when the Chinese stopped their overseas ventures. A strong case can be made that the loss of nerve suffered by the Chinese in that year ultimately led to their conquest by the Europeans in the 19th century and the downfall of their ancient civilization. There is a lesson in all of this that is self-evident for us today and we dare not ignore it.

The early exploratory voyages by the Europeans ultimately led to new settlements on the lands that were being discovered. Is there reason to believe that the same thing will happen once we establish bases on our nearest neighbors in the solar system? In this case, the European voyages of discovery are not much help as an analogy. In almost all instances, the Europeans who came as settlers to new lands found people living there already and, in some cases (Mexico for example), by highly developed civilizations as well. The question, therefore, of whether life is even possible in the newly discovered lands had already been answered in the affirmative. The same is not true of potential colonists who may wish to make new homes on the moon, the asteroids, Mars and perhaps on artificial colonies such as those proposed by Professor Gerard K. O'Neill.

Is there an analogy in human history that might shed some light on this question? Fortunately, there is and it is, if anything, more remarkable than the achievements of the early

Chinese and European explorers. Five hundred years before Prince Henry of Portugal began the era of navigation for the Europeans, and Chen-Ho's ships plied the Indian Ocean, a group of courageous people, who probably lived in the Southern Philippines or the islands to the south and west, started out on what are still the most remarkable voyages of discovery in human history. These people, using highly efficient and advanced sailing craft (canoes with outriggers and later on large double hulled catamarans) started to make the longest sailing voyages in history. They went in groups of 20 to 50 people and, in the course of the next four centuries, they settled and made habitable all of the islands in the vast Pacific from Fiji, New Zealand, Hawaii to the Marquesas, Tuamotus and finally to Easter Island at the very eastern extreme of their domain. These islands were completely uninhabited when these people--whom we now call Polynesians--arrived. Moreover, the islands were biologically poor--that is--there was little plant or animal life that could sustain comfortable human habitation. All of this meant that the Polynesians had to take their plants and animals with them on these remarkable journeys. In short, they were equipping themselves with the life support systems that they suspected they would need when they reached their far-flung destinations.

Not only did these remarkable people settle the Pacific Islands but they created flourishing civilizations ranging from the great Maori kingdom in New Zealand, the empire of Kamehameha in Hawaii to the mysterious and tragic group that settled on Easter Island, carved hundreds of great stone statues and then

disappeared. And all of this was done in an extremely short time. The best archeological evidence we have tells us that the Hawaiian Islands were settled for the first time around 1200 A.D. by a relatively small group of people--perhaps as few as fifty. We know this from the genetic evidence we can find in the Hawaiian native population. By the time Captain Cook reached Hawaii five and a half centuries later, he found a great and vigorous empire with an estimated population of 300,000 people.

Why did the Polynesians do all of this? What was their motivation? Undoubtedly, all of the usual reasons of population pressure, conflicts and laws of primogeniture played their part, but Professor Ben R. Finney of the University of Hawaii disagrees. He believes that there is a more basic reason which is somehow lodged in the fundamental nature of human beings. When homo erectus first moved from the Central African rain forest to the East African Savannah he was forced to hunt and to use tools--and most important--he was forced to roam and explore. Finney maintains that this two million year old nomadic instinct has not been completely bred out of the human species. This, he says, is the real reason why people move to settle new places and he maintains that this urge to move on will be the primary motivation for the eventual expansion of the human race into the solar system and later, perhaps, into the galaxy itself. This is the prospect that I wish to put before you, and it is, in my opinion, the real reason for our "Enterprise in Space."

Most of you in the graduating class of 1984 will be around by the year 2030. My guess is that you will live to see the

establishment of the first permanent human colonies on the moon and that perhaps some of you will even participate in this new human adventure. I have had the good fortune and the opportunity to help lay the foundations, and I hope to see the permanent Space Station established some time in the next decade. It is important to realize that this is only a first step and a means to a much more important end. My hope is that you will have the good fortune and the opportunity to carry on this great enterprise. Best of luck and thank you very much.